EDUCATIONAL MODULES

For LEARNING and to PRACTISE the ELECTRONICS

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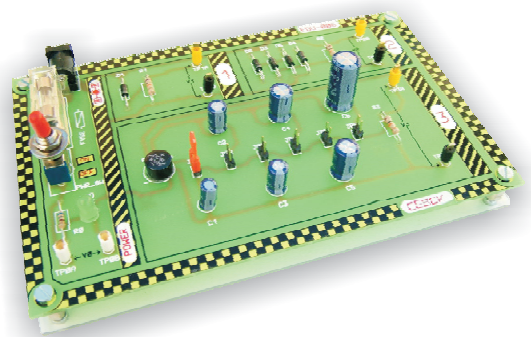
EDU-006. Rectifiers.



The practice EDU-006 includes four lessons or experiments allowing to compare and to observe the behaviour of different configurations for rectifiers bridges.
The practice is divided in 3 lessons. You only need a transformer or a power supply, an oscilloscope and a voltmeter to work on each experiment.
The original technical documentation of diodes' manufacturers is included. It will allow to the student to recognize specific characteristics of the component concerned by the concept operations.

- **Practice 1.** Medium wave rectifier . Positive half cycle, diode nominal current, design parameters.
- **Practice 2.** Rectifier bridge. Rectification Cycle of complete wave, current division between diodes...
- **Practice 3.** Rectifier bridge with capacitors. Capacitor incidence, overload current, ripple formula.
- **Practice 4.** Comparison between rectifier bridges. Current into diodes, real values and peak voltages.....

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Warranty and Do not forget.

Cebek educational modules included in the EDU serial offer several practices to analyse, experiment and to learn basic knowledge on the studied theme. Nevertheless, their function is not to make a mini-class on each theme, but to complete and to be used as basis, as well as to allow to experiment on the theoretical theme evocated by the teacher. For this reason, we suggest you to use modules form the EDU serial under the supervision and the direction of a teacher.

Cebek doesn't offer a consulting service as concern the theoretical or the operating principles concerning the theme deal with the module. It only offers a technical assistance regarding questions and problems coming from the circuit's internal operating mode.

All Cebek modules included in the EDU serial have a warranty of 3 years as concerning components and labour man. All damages provoked by external causes (from the circuit), as well as wrong connections or installations or due to an operating mode no indicated into the module's documentation won't be covered by the warranty. More over, all wrong or incorrect handling won't be excluded from the warranty. For any claim, you have to present the corresponding invoice.

To contact our technical department, you can send a message to sat@cebek.com, or a fax :Nº+34.93.432.29.95 or a mail to the following address: CEBEK, c/Quetzal, 17-21, 08014 Barcelona (SPAIN).

Rules and Identification of the EDU serial elements.

To make easier the identification and for a single rule as concern different practices and educational Cebek modules, all common elements will answer to colour code and to a shape.

Test Point. (TP).

It allows to connect oscilloscope's or multimeter extremities to read parameters relating to the practice. According to its colour, it will indicate that the Test Point (TP) is connected to the positive or to the negative of the circuit, as well as reads concerning current, voltage, load, etc….

TP. ⊕ circuit
Red

TP. ⊖ circuit
Black

TP. Tension
Yellow

TP. Courant
Blue

TP Without current or TP AC.
White

Conmutator / Switch.

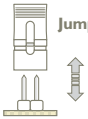
According to the colour of the switch, you can control the voltage, the current

Power supply
Red

Current
Blue

Voltage
Yellow

Logical
Green



Jumper.

It allows to close or open a signal or an electrical circuit

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Before to start...

Before to start a practice, it is very important to carefully read its instruction manual as well as corresponding indications.

You have to do correctly connections in indicated contact points, otherwise measures depending on these connections will be confuses or wrong.

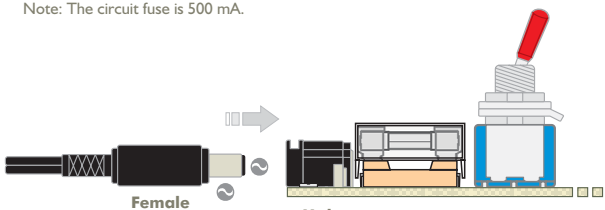
Do not make connections not indicated in the instruction manual to avoid to damage the circuit.
If the Led of the power supply "PWR" doesn't light on or if its function suddenly stops, you have to quickly disconnect the power supply for the device and check there is any short-circuit as well as the fuse's status.

Even if described practices can be done following instruction manual, we recommend you to use it under the supervision of a teacher who can advise and bring you a support (an help) concerning described concepts.

In the circuit, each practice will be delimited by a rectangle with the corresponding number. One or several experiment(s) can be reported and referenced to this practice.

Module's power supply.

The module has to be supplied at 12 V AC. For the secondary, you have to use a transformer with this voltage in the secondary and a current at least 500mA.
The circuit's feed is done through the male connector inserted on the board, **do not inject signal on any other terminal placed on the circuit**. Once supplied, the circuit offers necessaries voltages to make experiments with each practice. To connect the power supply, the module includes a cable wit a male connector at one extremity and wires at the other extremity.
Connect all terminals to the transformer output. Finally, you could insert it into the module.
Note: The circuit fuse is 500 mA.



Required Material.

You won't need any additional material or components to experiment with this module. You only need basis measure instruments to obtain and to compare obtained values from this practice. For this module, you will need an oscilloscope with one or two channels. If you have a voltmeter, you could also use it, but you can't appreciate results different from alternating signal.

Bibliography.

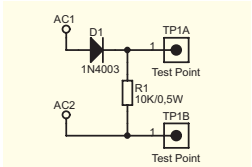
.- Electronics principles E. McGraw-Hill. Author: Albert Paul Malvino.
.- With Google: goodark roducts plastic rectifiers | goodark roducts Bridge rectifiers

Practice 1. Medium Wave Rectifier.

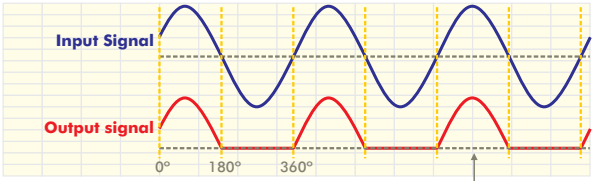
The current will have a specific behaviour if you operate with one or several diodes in determined circuits.
One of the most common diode's applications is the configuration converting it into a rectifier circuit for an alternating signal.

The practice N°1 explains the basic concept: the medium wave rectifier. The goal is to understand the circuit's behaviour, elaborating an input/output voltage table and a graphics with obtained values through an oscilloscope.

To develop this practice, you have to use both channels usually offered by the oscilloscope and the voltmeter.
You have to apply a probe of the channel 1 to the TP0, connecting the positive of the probe to the TP0B. These two terminals correspond to the input signal of the practice, indicated by AC1 and AC2 on the electrical drawing and internally injected by the module from the power supply input.
The probe of the channel n°2 has to be placed between tips test TP1A and TP1B, respecting their polarity between them (TP black = negative).
The oscilloscope adjustment is done as following. The double visualisation option of both channels has to be selected. The time basis has to be placed to 5 msec and both channels have to be adjusted to 5 or 10V/div, D.C.



Electrical Drawing Practice 1



(Vertical axis, moved to compare)

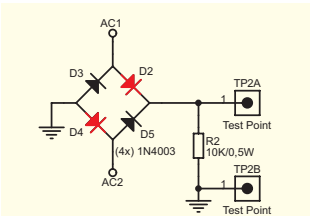
The input signal (TP0), 12 V AC, composed by a complete sinusoidal wave, reach the diode which, directly polarised, will only allow the voltages pass immediately superior to the elbow voltage (0,7V).
Without taking in account this value, we can say that during the positive half cycle, the diode conducts and operates like a closed switch and the output signal obtained on the load will be include between 0 and 180°. When the input signal reach the negative half cycle, the diode operates like an open switch and cut the signal stopping the conduction between 180 and 360°. Successive positive and negative half cycles compose the characteristic signal of the rectified output.
Then, placing a D.C voltmeter between TP1A and TP1B, you can verify as the obtained effective value is not the same than the peak voltage indicated on the oscilloscope.

Practice 2. Rectifier Bridge.

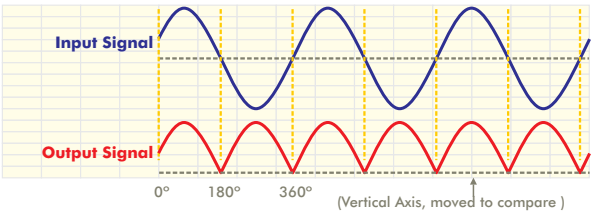
The bridge rectifier is the best rectifier's configuration. It has 4 diodes operating in "bridge" and offering best results than the Medium Wave rectifier.
Thanks to numerous advantages offered, the EDU-006 module is the most used in the industrial field and it use has been so common that several manufacturer includes inside a single piece, the fours diodes. The box dimension will vary and it is classified according to the maximum current accepted by the bridge.

The practice nº2 allows to compare output peak voltage values as well as different rectification signal thanks to the oscilloscope.

In this practice, it is not necessary to check at the same time the input signal and the output signal. The input signal from the practice Nº2 can be used as reference. If the probe of the channel 1 is still connected, you have to disconnect it. If you sampling, at the same time, input and output signals from this practice, a short-circuit will be produced and the fuse will be destroyed due to the oscilloscope's internal connection. You only have to place the probe of the channel nº2 between tips test TP2A and TP2B, respecting their polarity (TP black = negative). As concern the oscilloscope adjustment, you can ignore the double visualization option, selecting only the channel 2. The rest of adjustments have to be done as in the previous practice. The time basis established in 5 msec, and the channel 2 has to be adjusted to 5 or 10V/Div, DC.



Electrical Drawing Practice 2



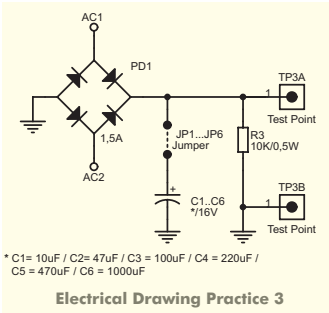
When the positive half cycle reach the net composed by the fours diodes; D2 and D4, directly polarised, allows the current pass and the signal is obtained through the load. Then, D3 and D5 are inversely polarised and don't operate. Nevertheless, during the positive half cycle, D2 and D4 don't conduct, D3 and D5 remain in direct polarisation, the signal pass and the load voltage being positive; for this reason there are positive half cycles at each complete cycle.
Finally, if you place a D.C voltmeter between TP2A and TP2B, the effective value is different to the half wave rectifier one.

Practice 3. Rectifier bridge with Capacitor.

The medium wave rectifier as well as the bridge rectifier offer a D.C push voltage, far away from the constant voltage required by almost electronic circuits as power supply. To obtain a signal near to the ideal one, like the supplied by a battery, you have to add a stabiliser filter.

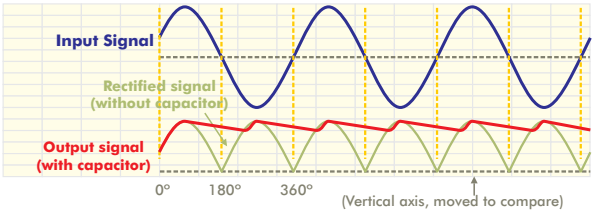
The practice n°3 shows the filter effect obtained through the electrolytic capacitor, and its influence on the final ripple of the rectified DC signal.

As for the rest of these exercises, the input signal is always the same, for this reason it is not necessary to display it. You only have to connect the probe of the oscilloscope's channel N°2 to the TP3A and TP3B, respecting their polarity. The oscilloscope adjustment will remain in single visualisation of the channel N°2, times basis placed in msec, and 5 to 10V per D.C division.
Initially, all jumpers have to be open. Each one connects the corresponding capacitor between the rectifier bridge and the load.



Electrical Drawing Practice 3

Without jumper, and therefore without filter capacitor, the circuit is exactly identical to the circuit of the practice N°2. The single difference is the fact that the fours diodes are now grouped into a single piece. Therefore, the output signal and the effective value of the direct voltage are equal to the previous exercise ones.
Then, if you close the Jumper N°1, the push signal will be converted to a filtered signal, near to an horizontal line, like the added figure.



During the slope ramp of the positive half cycle, the capacitor is charged till to reach the peak value, thanks to the diodes' direct polarisation who acts as a closed switch, allowing the current to pass. After the positive peak the signal should fall, but the capacitor, still supplied by the load, maintain the voltage. Because of the load's consumption, the voltage proportionally decreases according to the current needs of the load, till the capacitor is recharged with the new slope ramp and the cycle is renewed.
More the capacitor's capacity is high, less is the load consumption, and more the output signal will be linear, or at the opposite you will have a widest ripple.

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Practice 4. To calculate peak voltage, Load current, obtained values...

To design (conceive) a rectifier bridge, you have to use suitable components, like diodes and capacitors, according to current and voltages that you want to use.

Practice 4a. Medium Wave Rectifier. Formula and Values.

Firstly you have to establish the peak voltage (Vp), that you can obtain after the rectification of the transformer's secondary (V2).
Supposing that you will apply a 12 V voltage to the module input, the Vp obtained in the load will be: 12 / 0,707 = 16,97, less 0,7 V of the diode= 16,3 Vp.

$$Vp = \frac{V_2}{0,707} - Vd$$

V_2= V. Secondarye Vp = V. Pic Vd = V. diode

The effective voltage (Vdc) obtained reading the direct current on a voltmeter is due to a push signal increase present after the rectification.
Using again the previous value of Vp (16,3V), you would obtain an effective voltage in the load of 16,3 / p = 5,19 Vdc.

$$Vdc = \frac{Vp}{}$$

* **To calculate the diode value** you have to take in account **the inverse peak voltage as well as the diode current.**

In the medium wave rectifier, all the current in the load will directly circulate through the diode, for this, you have to read technical characteristics described by the manufacturer and then select the suitable diode. For instance, the 1N4003 diode used in the practice can support 1A as maximum. The maximum inverse voltage or peak inverse voltage, is produced during the maximum point of the negative half cycle; point that the diode has to withhold in its inverse polarisation.
For this reason, during the design, you have to use a diode able to support the inverse Vp and to avoid its break point. On the practice N°1 the Vp is 16,3V, then the peak inverse voltage is also 16,3V. The 1N4003 diode can support 50V as maximum to operate with this signal.

Practice 4b. Rectifier bridge. Formula and Values.

The Vp voltage is the same that in the medium wave rectifier. In the practice, Vp= 16,3V. The effective voltage, thank to a configuration in net of the bridge rectifier, allows that all signal of the secondary reach the load, the average of the signal and therefore the effective voltage is superior to the medium wave rectifier one.
Using again the previous value of Vp (16,3 V), you would obtain an effective voltage in the load of (2X16,3) / p = 10,37 Vdc.

$$Vp = \frac{V_2}{0,707} - Vd \qquad Vdc = \frac{2Vp}{}$$

V_2= V. Secondary Vp = V. Pic Vd = V. diode

* **To calculate the diode value** you have to take in account **the inverse peak voltage as well as the diode current.**

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Practice 4b. Rectifier Bridge. Formula and Values. (2nd Part).

As concern the diodes' conception, the current which flows through the load (Ic), is divided between two diodes but the peak inverse voltage is identical to the voltage of the medium wave rectifier; therefore the final current flowing through each diode will be equal to the half of load current (0,5 x Ic).
In the case of the practice N°2, each 1N4003 will dissipate 50% the power less than the practice N°1.
In order to select the rectifier bridge, the manufacturer will indicate the maximum current which can cross the diode. For the practice N°3, the bridge allows 1,5A as maximum current.

Practice 4c. *Ripple voltage. Formula and Values.*

As it is described in the practice n°3, the rectifier bridge with input capacitor emits a direct current signal almost linear in the load. The no eliminated fluctuation, named ripple voltage will depend on the capacitor's capacity.
The ripple voltage (Vrz) can be obtained through a formula, dividing the load voltage (Ic) between the product of the ripple frequency (Frz) and the capacitor filter's capacity (C). Considering that the ripple frequency is two times higher into the rectifier bridge than into the medium wave; formulas will be the following ones:

Rect. Bridge: $Vrz = \frac{Ic}{2(Frz) \times C}$ Medium Wave Rect.: $Vrz = \frac{Ic}{Frz \times C}$

Vrz= V. ripple
Ic = Max. Load current .
Frz = Ripple frequency , (line frequency)
C= Capacitor

Contrary to the logical thought, it is not necessary to reduce the Vrz to the maximum. Because of the presence of other effects as overload voltage and complementary filtering obtained from voltage regulators, there is a design concept, very used to find the suitable value of a capacitor.
To find the equilibrium in the capacitor's capacity, maintaining the Vrz as low as possible, you have to establish the 10% rule, indicating that the Vrz has to approximately represent 10% of the peak voltage (Vp).
According to te values of the practice n°3, if Vp= 16,3V, the Vrz should be 1,6V.
Therefore, applying the formula, the capacitor value will be :

$$\frac{1{,}037mA}{100Hz \times 1{,}6V} = 6{,}48uF$$

As there is no commercial capacitor having a value of 6,48 uF, the approximate suitable value would be 10 uF.

*** To calculate the capacitor's value you can use the 10% rule : Vrz = 10% Vp.**